Control Account Status Report HL-LHC CMS Detector Upgrade 402.04.04.05 CE Module Assembly UCSB

Change log

Date	Name	Description
2-17-25	S. Nahn	Initial Template
2-23-25	S. Nahn	Original draft
3-17-25	N. Akchurin	First draft
3-18-25	J. Alison	Second draft
6-24-26	S. Nahn	Updated data for 2026 IPR
6-30-26	N. Akchurin	First draft
7-10-26	J. Alison	Updates for consistency with other MACs

Scope

This control account covers the scope for the fabrication activities at Module Assembly at UCSB, consisting of the design of the standard module assembly procedures, the assembly of odd-sized modules during module production, their testing during the assembly process, quality control (QC) of produced modules, and shipping of the odd-sized modules to the cassette production sites.

Link to Work Breakdown Structure: CMS-doc-13213

Link to WAD: CMS-doc-14003

Technical Progress

The silicon module construction involves three components (baseplate, silicon sensor, and hexaboard) that are precisely stacked and glued together using an automated gantry. The gantry system with specialized pick-up tools, fixtures, and control software are in place. The wire-bonding, encapsulation, and a single module testing station for the final QC are also at hand. Module construction was originally foreseen to only use epoxy for adhesive. Because the PCB can arrive too warped to laminate with epoxy alone, we moved to a "hybrid" adhesive strategy, using a combination of epoxy and transfer tape. The hybrid adhesive strategy also reduces the latency of producing a module; with epoxy-only construction requires two overnight curing steps, with the hybrid scheme a module can be assembled in a single day. This change will thus lead to improved module quality and decreased time to produce a module.

The ramp-up process to produce multiple modules is progressing well and the plan is now to build 16 full-size equivalent modules a day at peak production. The rate has been demonstrated during week long sprint exercises. The multi-module test system (MMTS) has been developed, the parts have been produced, and the system is fully installed in the lab. All modules produced thus far (>300) have been thermally cycled at least once in MMTS. The second thermal cycling has started and the modules that pass the first thermal cycling tend to pass the second thermal cycling test (roughly 98%).

Earned Value performance

Past year performance

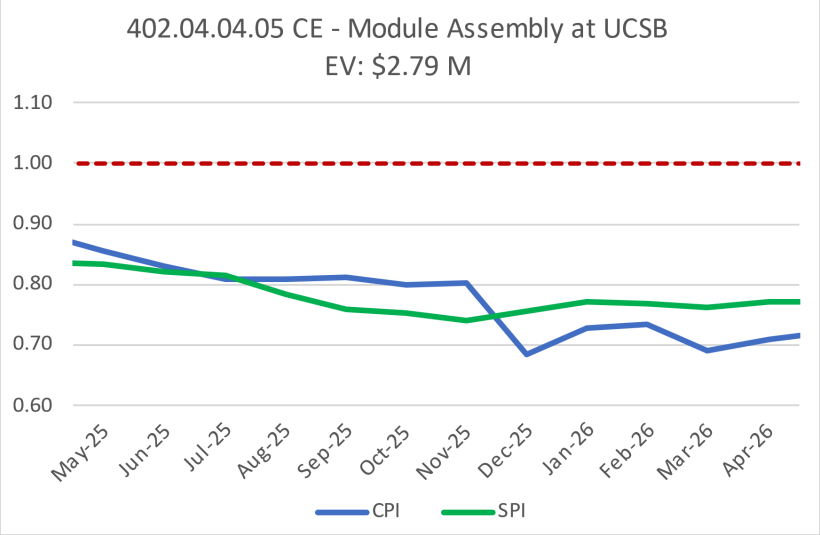

Figure 1 Performance of Control Account 402.04.04.05

The silicon module production has been delayed due to hold up in baseplate and hexaboard/HGCROC availability. The baseplate material had to be changed from carbon fiber to Ti to provide additional stiffness and better thermal conductivity. In the case of HGCROCs, various essential fixes required additional submissions. The changes are now implemented, and enough components are made available to the MACs for ramp-up. While the schedule variance hovered around SPI~0.8 due to these delays, the cost variance has been also declining due to standing army costs to 0.7 from 0.85 in May 2025.

Variance Links: [1]

May-25	Jun-25	Jul-25	Aug-25	Sep-25	Oct-25	Nov-25	Dec-25	Jan-26	Feb-26	Mar-26	Apr-26	May-26

Analysis of Estimate to Complete

The remaining Estimate to Complete is $1,075k of labor and $157k in Materials and Supplies (M&S). These funds will cover the production of modules at UCSB and support of both the domestic and international module factories.

The UCSB site will produce the odd sized modules at the inner and outer areas of both the electromagnetic and hadronic portions of the endcap calorimeter plus some high-density (HD) full-size modules for load balance among the US Module Assembly Centers (MACs). Thus far, 20% of modules have been produced. The remaining labor budget covers the production and

[1] Variance reporting is done through the FFDG camEToolbox online interface. For access, please consult with the Project Management

testing of these modules. The group will also provide consulting and support to all other module assembly factories (domestic and international) that are working on the endcap calorimeter.

The Basis-of-Estimate assumed production of 6 “full-size equivalent” (FSE) modules simultaneously on the gantry, reaching a steady production rate of 12 FSE modules per day. However, based on experience gained from making the pre-series modules and adjustments due to the revised hybrid adhesive strategy, we now plan to produce 4 FSE modules simultaneously on the gantry at an increased steady production rate of 16 FSE modules per day. The detailed bottom-up labor estimate for the various assembly tasks has been redone assuming the new production cadence and is available in the ScopeSpreadsheet in [Ref-1]. The new assessment of labor requirements is a few percent lower than the original projection. This provides confidence that the project will be completed within budget. Although overall labor requirements remain similar, the adjustments in the assembly strategy will allow modules to be produced faster (by a factor of 16/12) than originally planned.

The remaining M&S budget covers cleanroom consumables (adhesive tape, epoxy, etc.) and module shipping costs. These expenses scale directly with the number of modules produced and thus remain unaffected by changes in production rate. Experience from pre-series modules has validated the original M&S estimate, again within the anticipated uncertainty.

Risk evolution and remaining risks

The risk of infrastructure failure (RT-402-4-02-D) remains open for the rest of this project. To mitigate schedule delays and standing army costs, we use uniform procedures at all MACs. We also allow some excess assembly capacity. In the case of a serious failure, some staff and production work can be transferred to the other MACs, possibly adding a weekend day to the shift cycle.

We do not anticipate any additional BCRs for this control account.

Related Documents

[Ref-1] The latest version of this document is available here:

https://cms-docdb.cern.ch/cgi-bin/DocDB/ShowDocument?docid=14208